

CLAIMS

WHAT IS CLAIMED IS:

1. A polymer composition consisting essentially of branched crystalline polypropylene homopolymer prepared in a polymerization process comprising: combining two or more different metallocene catalyst compounds; said polypropylene homopolymer having a unimodal molecular weight distribution and a heat of fusion of 70 J/g or more.
2. The composition of claim 1, in which the heat of fusion of the branched crystalline polypropylene is 80 J/g or more.
3. The composition of claim 1, in which the heat of fusion of the branched crystalline polypropylene is 90 J/g or more.
4. The composition of claim 1, in which the Heat of fusion of the branched crystalline polypropylene is 100 J/g or more.
5. The composition of claim 1, in which the Branching Index of the branched crystalline polypropylene is 0.98 or less.
6. The composition of claim 1, in which the Branching Index of the branched crystalline polypropylene is 0.95 or less.
7. The composition of claim 1, in which the Branching Index of the branched crystalline polypropylene is 0.90 or less.
8. The composition of claim 1, in which the Branching Index of the branched crystalline polypropylene is 0.80 or less.

9. The composition of claim 1, in which the two or more metallocene catalyst compounds include a first metallocene compound and a second metallocene compound; the first metallocene compound capable of forming vinyl, vinylene, or vinylidene terminated polypropylene macromer with a weight average molecular weight of less than 150,000 Daltons; and the second metallocene compound is capable of forming a crystalline polypropylene with a weight average molecular weight of 100,000 Daltons or more; wherein the molar amount of the second metallocene compound is greater than the molar amount of the first metallocene compound.
10. The composition of claim 1, in which one of the metallocene compounds includes an ethylene-bridged bis-indenyl hafnocene or an ethylene-bridged bis-tetrahydroindenyl hafnocene.
11. The composition of claim 1, in which one of the metallocene compounds is rac-1,2-ethylenebis(4,7-dimethyl-indenyl)hafnium dichloride or rac-1,2-ethylenebis(4,7-dimethyl-indenyl)hafnium dimethyl.
12. A unimodal polymer composition comprising branched crystalline polypropylene, prepared by the process comprising:
combining two or more different metallocene catalyst compounds with propylene monomers in a polymerization medium having less than 30 volume percent diluent;
conducting polymerization of the propylene monomers in the polymerization medium at a reaction temperature of 75°C or less; and
recovering a branched crystalline polypropylene that has (a) from 0.0 wt% to 2.0 wt% ethylene; (b) a heat of fusion of 70 J/g or more; and (c) a unimodal molecular weight distribution.
13. The composition of claim 12, in which the polymerization medium consists essentially of propylene monomers.

14. The composition of claim 12, in which the heat of fusion of the branched crystalline polypropylene is 60 J/g or more.
15. The composition of claim 12, in which the heat of fusion of the branched crystalline polypropylene is 70 J/g or more.
16. The composition of claim 12, in which the heat of fusion of the branched crystalline polypropylene is 90 J/g or more.
17. The composition of claim 12, in which the Branching Index of the branched crystalline polypropylene is 0.98 or less.
18. The composition of claim 12, in which the Branching Index of the branched crystalline polypropylene is 0.95 or less.
19. The composition of claim 12, in which the Branching Index of the branched crystalline polypropylene is 0.90 or less.
20. The composition of claim 12, in which the Branching Index of the branched crystalline polypropylene is 0.80 or less.
21. The composition of claim 12, in which the two or more metallocene catalyst compounds include a first metallocene compound and a second metallocene compound; the first metallocene compound capable of forming a polypropylene macromer with a weight average molecular weight of less than 150,000 Daltons; and the second metallocene compound is capable of forming a crystalline polypropylene with a weight average molecular weight of 100,000 Daltons or more; wherein the molar amount of the second metallocene compound is greater than the molar amount of the first metallocene compound.

22. The composition of claim 12, in which one of the metallocene compounds includes an ethylene-bridged bis-indenyl hafnocene or an ethylene-bridged bis-tetrahydroindenyle hafnocene.
23. The composition of claim 12, in which one of the metallocene compounds is rac-1,2-ethylenebis(4,7-dimethyl-indenyl)hafnium dichloride or rac-1,2-ethylenebis(4,7-dimethyl-indenyl)hafnium dialkyl.
24. A polymer composition that comprises branched crystalline polypropylene, prepared by the process comprising: conducting polymerization of propylene monomers in the presence of a first metallocene catalyst compound and a second metallocene catalyst compound at a temperature of 75°C or less to provide a composition that comprises branched crystalline polypropylene containing from 0.0 wt% to 2.0 wt% ethylene, wherein:
 - (a) the first metallocene catalyst compound is capable of producing vinyl terminated polypropylene macromers; and
 - (b) the second metallocene catalyst compound is capable of producing crystalline polypropylene having a weight average molecular weight of 100,000 Daltons or more.
25. The composition of claim 24, in which the polymerization medium consists essentially of propylene monomers.
26. The composition of claim 24, in which the heat of fusion of the branched crystalline polypropylene is 80 J/g or more.
27. The composition of claim 24, in which the heat of fusion of the branched crystalline polypropylene is 90 J/g or more.
28. The composition of claim 24, in which the heat of fusion of the branched crystalline polypropylene is 100 J/g or more.

29. The composition of claim 24, in which the Branching Index of the branched crystalline polypropylene is 0.98 or less.
30. The composition of claim 24, in which the Branching Index of the branched crystalline polypropylene is 0.95 or less.
31. The composition of claim 24, in which the Branching Index of the branched crystalline polypropylene is 0.90 or less.
32. The composition of claim 24, in which the Branching Index of the branched crystalline polypropylene is 0.80 or less.
33. The composition of claim 24, in which one of the metallocene compounds includes an ethylene-bridged bis-indenyl hafnocene or an ethylene-bridged bis-tetrahydroindenyl hafnocene.
34. The composition of claim 24, in which one of the metallocene compounds is rac-1,2-ethylenebis(4,7-dimethyl-indenyl)hafnium dichloride or rac-1,2-ethylenebis(4,7-dimethyl-indenyl)hafnium dialkyl.
35. A branched crystalline polypropylene composition prepared by the process comprising:
 - contacting a polymerization mixture that includes propylene monomers with a first metallocene catalyst compound and a second metallocene catalyst compound; and
 - conducting polymerization of the propylene monomers for a time sufficient to form a branched crystalline polypropylene composition having a heat of fusion of 50 J/g or more, wherein:
 - the first metallocene compound is an alkyl bridged metallocene compound that has at least two indenyl rings or derivatives of indenyl rings, each ring being substituted at the 4 and 7 positions;

the second metallocene compound is a bridged metallocene compound that has at least two indenyl rings or derivatives of indenyl rings, each ring being substituted at the 2 and 4 positions.

36. The composition of claim 35, in which the polymerization medium consists essentially of propylene monomers.
37. The composition of claim 35, in which the Heat of fusion of the branched crystalline polypropylene is 80 J/g or more.
38. The composition of claim 35, in which the Heat of fusion of the branched crystalline polypropylene is 90 J/g or more.
39. The composition of claim 35, in which the Heat of fusion of the branched crystalline polypropylene is 100 J/g or more.
40. The composition of claim 35, in which the Branching Index of the branched crystalline polypropylene is 0.98 or less.
41. The composition of claim 35, in which the Branching Index of the branched crystalline polypropylene is 0.95 or less.
42. The composition of claim 35, in which the Branching Index of the branched crystalline polypropylene is 0.90 or less.
43. The composition of claim 35, in which the Branching Index of the branched crystalline polypropylene is 0.80 or less.
44. The composition of claim 35, in which one of the metallocene compounds includes an ethylene-bridged bis-indenyl hafnocene or an ethylene-bridged bis-tetrahydroindenyle hafnocene.

45. The composition of claim 35, in which one of the metallocene compounds is rac-1,2-ethylenebis(4,7-dimethyl-indenyl)hafnium dichloride or rac-1,2-ethylenebis(4,7-dimethyl-indenyl)hafnium dialkyl.
46. A polymer composition comprising branched crystalline polypropylene having a heat of fusion of 70 J/g or more; a Branching Index of 0.98 or less; a unimodal molecular weight distribution; and from 0.0 wt% to 2.0 wt% ethylene.
47. A polymer composition comprising branched crystalline polypropylene having a Heat of fusion of 70 J/g or more; a Branching Index of 0.98 or less; a unimodal molecular weight distribution; and from 0.0 wt% to 2.0 wt% ethylene.
48. A polymer composition comprising branched crystalline polypropylene having a heat of fusion of 80 J/g or more; a Branching Index of 0.98 or less wherein said branching is derived solely from polypropylene macromers; and a unimodal molecular weight distribution.
49. A polymer composition comprising branched crystalline polypropylene homopolymer having a Heat of fusion of 80 J/g or more; a Branching Index of 0.95 or less wherein said branching is derived solely from polypropylene macromers; and a unimodal molecular weight distribution.
50. A composition comprising the combination of the polymer composition of claim 1 and one or more olefin polymers selected from the group consisting of: ethylene propylene rubber, ethylene propylene diene monomer rubber, neoprene rubber, styrenic block copolymer rubbers (including SI, SIS, SB, SBS, SIBS rubbers), butyl rubber, halobutyl rubber, star branched butyl rubber, copolymers of isobutylene and para-alkylstyrene, halogenated copolymers of isobutylene and para-alkylstyren, homopolypropylene, propylene copolymerized with up to 50 weight % of

ethylene or a C4 to C20 alpha.-olefin, isotactic polypropylene, highly isotactic polypropylene, syndiotactic polypropylene, random copolymer of propylene and ethylene and/or butene and/or hexene, polybutene, ethylene vinyl acetate, low density polyethylene (density 0.915 to less than 0.935 g/cm³) linear low density polyethylene, ultra low density polyethylene (density 0.86 to less than 0.90 g/cm³), very low density polyethylene (density 0.90 to less than 0.915 g/cm³), medium density polyethylene (density 0.935 to less than 0.945 g/cm³), high density polyethylene (density 0.945 to 0.98 g/cm³), ethylene vinyl acetate, ethylene methyl acrylate, copolymers of acrylic acid, polymethylmethacrylate or any other polymers polymerizable by a high-pressure free radical process, polyvinylchloride, polybutene-1, isotactic polybutene, ABS resins, nylons (polyamides), polycarbonates, PET resins, crosslinked polyethylene, copolymers of ethylene and vinyl alcohol (EVOH), polymers of aromatic monomers such as polystyrene, poly-1 esters, high molecular weight polyethylene having a density of 0.94 to 0.98 g/cm³ low molecular weight polyethylene having a density of 0.94 to 0.98 g/cm³, graft copolymers, generally, polyacrylonitrile homopolymer or copolymers, thermoplastic polyamides, polyacetal, polyvinylidene fluoride and other fluorinated elastomers, polyethylene glycols and polyisobutylene.

51. The composition of claim 50, wherein the polymer composition is present in the blend at from 10 to 99 weight %, based upon the weight of the polymers in the blend.
52. The composition of claim 50, wherein the polymer composition is present in the blend at from 30 to 90 weight %, based upon the weight of the polymers in the blend.
53. The composition of claim 50, wherein the polymer composition is present in the blend at from 20 to 95 weight % based upon the weight of the polymers in the blend.

54. The composition of claim 50, wherein the polymer composition is present in the blend at from 40 to 90 weight % based upon the weight of the polymers in the blend.
55. The composition of claim 50, wherein the polymer composition is present in the blend at from 50 to 90 weight % based upon the weight of the polymers in the blend.
56. The composition of claim 50, wherein the polymer composition is present in the blend at from 60 to 90 weight % based upon the weight of the polymers in the blend.
57. The composition of claim 50, wherein the polymer composition is present in the blend at from 70 to 90 weight % based upon the weight of the polymers in the blend.
58. A foam comprising the composition of claim 1.
59. A blow molded article comprising the composition of claim 1.
60. A thermoformed article comprising the composition of claim 1.
61. A film comprising the composition of claim 1.
62. A fiber comprising the composition of claim 1.
63. A sheet comprising the composition of claim 1.
64. A plaque comprising the composition of claim 1.
65. A hose comprising the composition of claim 1.

66. A belt comprising the composition of claim 1.
67. A tire comprising the composition of claim 1.
68. A tape comprising the composition of claim 1.
69. A nonwoven fabric comprising the composition of claim 1.
70. A wax crystal modifier comprising the composition claim 1.
71. A dynamically vulcanized alloy comprising an elastomer and the polymer composition of claim 1.
72. The dynamically vulcanized alloy of claim 71 wherein the elastomer comprises one or more of ethylene propylene rubber, ethylene propylene diene monomer rubber, neoprene rubber, styrenic block copolymer rubbers (including SI, SIS, SB, SBS, SIBS rubbers), butyl rubber, halobutyl rubber, star branched butyl rubber, copolymers of isobutylene and para-alkylstyrene, halogenated copolymers of isobutylene and para-alkylstyrene, brominated copolymers of isobutylene and para-methylstyrene, polyisobutylene, natural rubber, and nitrile rubber.
73. The dynamically vulcanized alloy of claim 71 or 72 further comprising an engineering resin selected from the group consisting of polyamides, polyesters, polycarbonates, polysulfones, polyacetals, polylactones, acrylonitrile-butadiene-styrene resins, polyphenylene oxide, polyphenylene sulfide, styrene-acrylonitrile resins, styrenemaleic anhydride, polyimides, aromatic polyketones, and mixtures thereof.
74. An adhesive comprising the polymer composition of claim 1 and a tackifier selected from the group consisting of aliphatic hydrocarbon

resins, aromatic modified aliphatic hydrocarbon resins, hydrogenated polycyclopentadiene resins, polycyclopentadiene resins, gum rosins, gum rosin esters, wood rosins, wood rosin esters, tall oil rosins, tall oil rosin esters, polyterpenes, aromatic modified polyterpenes, terpene phenolics, aromatic modified hydrogenated polycyclopentadiene resins, hydrogenated aliphatic resin, hydrogenated aliphatic aromatic resins, hydrogenated terpenes and modified terpenes, and hydrogenated rosin esters.